Quasi-static Process Modeling of Deep Cold Rolling on Ti-6Al-4V

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Abstract

Deep cold rolling (DCR) is a mechanical surface treatment process which plastically deforms the surface and near sub-surface layer of the treated component. This generates a layer of compressive residual stress which improves fatigue life. Current DCR research is experimentally driven and existing finite element models do not take the varying process parameters into account.

This paper proposes a 3D implicit finite element model for the deep cold rolling process, developed using the commercially available Abaqus/Standard FE software. The model is then validated with experimental data obtained via the central hole drilling method.

It is shown that deep cold rolling can be modelled as a quasi-static process. This implicit process modeling method yields a model with accurate residual stress distributions which is used to better understand and predict the effect of varying process parameters, such as pressure and tool diameter, on the residual stress map. It is observed that increasing pressure generally causes higher plastic strain, leading to the entire compressive residual stress profile being pushed deeper into the material, but also causes higher distortion. It is also found that increasing the tool diameter increases the depth of influence while decreasing the level of compressive residual stress in the surface region.

Topics

Residual stress modelling methods, Residual stresses in manufacturing process